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Time reference teased apart from tense: Thinking beyond the present

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ABSTRACT

Reference to a time frame in which an event takes place can be done by verb inflection. If the time frame (past, present, future) is set by a temporal adverb, the verb inflection should correspond (yesterday he *walked*; today he *walks*). Temporal violations by simple verbs (single, lexical verbs inflected with tense) in the present tense and with present time reference elicit a P600 effect (Dragoy et al., 2012; Baggio, 2008). However tense does not always coincide with time reference; in languages such as Dutch and English, reference to the past can be established by using the present tense in the present perfect (e.g. ‘he has eaten the cake’). The current study investigates whether the P600 effects described by Dragoy et al. and Baggio are caused by tense or time reference violations of the verb. In the context of a past adverb, ERP responses to auxiliaries in present tense with either congruent past time reference or incongruent non-past time reference were compared. The findings show that the P600 effect for violations of the temporal context is caused by the time reference of the complete verb form, rather than by the tense.

Keywords: time reference; tense; discourse-linking; ERP: P600; periphrastic verbs; auxiliary

1 Introduction

The use of verb morphology to express temporal relations has been widely studied in linguistics. Languages such as English and Dutch use verb inflections for both tense and aspect. *Tense* provides information about *when* an event happens/happened. More precisely, it contains information about the temporal relation, such as ‘simultaneity’ or ‘precedence,’ between the time interval of the event expressed through the verb morphology and the time of evaluation set by the context. The evaluation time can be, for example, the speech time (the time of the speaker’s context) or the time of the matrix clause event. *Aspect* further specifies temporal relations by providing information about the boundaries (beginning, end point) of a situation. It tells the listener whether the event is seen as completed or as ongoing (Comrie, 1976). There is a clear distinction between tense and time reference, both of which are characteristics of temporal relations. *Tense* is a morphological element within a finite (i.e. tense-inflected) verb, while *time reference* is a semantic feature of the event being described and is a characteristic of a verb complex as a whole. It is the combination of tense, aspect and context that specifies the time reference. The difference between tense and time reference becomes clearest when present tense is used in a construction that refers to the past, which is possible in Dutch, for example. This will be further elaborated in the current study.

The outline is as follows: In the introduction, more theoretical background on time reference will be provided. Then, findings from aphasia will be discussed that demonstrate that for agrammatic speakers reference to the past is selectively impaired. In agrammatic aphasia, the time reference deficit is irrespective of tense, because past time reference by a construction containing a present tense auxiliary is also impaired. The distinction between past and present seems also to exist for non-brain-damaged adults. An ERP study by Dragoy, Stowe, Bastiaanse and Bos (2012) in healthy individuals showed differential responses to present and past time reference violations. This study does not reveal whether the differential neural responses for past vs. non-past reported in Dragoy et al. (2012) are due to tense morphology per se or to time reference. The aphasiological data would predict the latter. The goal of the current experiment is to investigate whether it is in fact tense or time reference which evoked the ERP effects in Dragoy et al. (2012).

1.1 Theoretical background on time reference and discourse linking

Tense and aspect can be expressed on a single lexical verb, called a ‘simple verb form,’ for example *writes*. If the verb form consists of an auxiliary plus a lexical verb, it is called a ‘periphrastic verb form,’ for example *has written* or *will write*, as illustrated in the Dutch sentences in (1) and (2). *Heeft*: ‘has’ and *gaat*: ‘will’ are both inflected for tense and agreement and are called *temporal auxiliaries*, because they are used for time reference.

- (1) De man heeft de brief geschreven.
the man has_{present tense} the letter written_{past participle}
The man has written¹ the letter.
- (2) De man gaat de brief schrijven.
the man will_{present tense} the letter write_{infinitive}
The man will write the letter.

Note that the Dutch construction [have + participle] refers to past time much more generally than the present perfect of English, which focuses on completion before the evaluation time (the moment of speaking).

These examples show that present tense can be decoupled from present time reference, since it can refer to different time frames depending on whether it occurs on a simple or periphrastic verb form, and on which periphrastic verb form it occurs. In (1), the present tense of the auxiliary *heeft*: ‘has’ is used in combination with the participle *geschreven*: ‘written’ to refer to a point prior to the evaluation time. In (2), the auxiliary in present tense *gaat*: ‘will,’ when combined with an infinitive, refers to the non-past (i.e. the future). In examples (1) and (2), at *heeft*: ‘has’ and *gaat*: ‘will,’ the listener may already interpret the time reference of the periphrastic verb form, even though the past participle or infinitive has not yet been encountered. This system of periphrastic verb forms creates a paradox in which a verb in present tense can be used to refer to the past, as in (1), as well as to the non-past (here future), as in (2).

¹ The meaning of the Dutch present perfect is closer to the English simple past than to the English present perfect, but to indicate that it is a periphrastic verb form, throughout this article the literal translation (e.g. ‘has written’) will

In order to interpret the verb tense more than superficially, it is necessary to refer to the time specified in the discourse context. Tense is therefore considered to be anaphoric in nature, in the sense that it is used to refer to a more specific time frame which is set by the previous context (Reichenbach, 1947; Partee, 1973; Aronson, 1977; Enç, 1987). Therefore, it has been suggested that tense is ‘discourse linked,’ or in terms of Avrutin (2006), processed by ‘discourse syntax.’ Zagona (2003), however, points out that the present tense is less dependent on discourse context than the past. According to her, in present tense the moment of speaking and the event coincide. That is, present tense is locally ‘bound’ to the moment of speaking rather than being linked to discourse. Only the past tense needs to be discourse-linked.

In line with Aronson (1977) and Partee (1973), Zagona (i.p.) proposes that future tense should be seen as a form derived from the present tense via modal and aspectual features and is, therefore, a sub-class of present tense. This view is adopted here, and only a distinction between past and non-past time reference will be made. It is assumed that reference to the past is discourse linked and reference to the non-past is not.

1.2 Neuro- and psycholinguistic background

The research question of the current experiment has its roots in aphasiology. Tense inflection is problematic for people with aphasia (Friedmann & Grodzinsky, 1997; Wenzlaff & Clahsen, 2004; Farooqi-Shah & Thompson, 2007). According to Bastiaanse (2008; Bastiaanse, Bamyaci, Hsu, Lee, Yarbay Duman & Thompson, 2011), however, the idea that tense is what is impaired is both too narrow and too broad. The view is too narrow, because the problems are not restricted to tensed verbs, but extend to periphrastic verb forms. It is too broad because the deficit is highly selective: verb forms referring to the past are impaired, whereas verb forms referring to non-past are relatively spared. Based on an extensive review of aphasiological production and comprehension data, Bastiaanse et al. (2011) formulated the PAST DIscourse LInking Hypothesis (PADILIH) to describe the pattern of relatively spared time reference to the present in production and comprehension. The PADILIH claims that reference to the past is discourse linked, regardless of the anaphoric means employed (i.e. not only through tense as suggested by Zagona, 2003). This explains the problems specific to the past found in individuals with agrammatic aphasia since discourse linking is impaired in agrammatic aphasia (see Avrutin, 2000; 2006). Therefore, reference to the past through any form of grammatical morphology,

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including simple past tense verbs, perfect aspect, periphrastic verb forms and perfective aspectual adverbs (used for time reference in many East Asian languages), are difficult in agrammatic aphasia.

1.2.1 Behavioral evidence from healthy processing

One of the issues in neurolinguistic research is to what extent the language problems of aphasic individuals are related to linguistic complexity. Possibly, the constructions that are vulnerable in aphasia are also associated with greater memory load or processing difficulty for the healthy brain. It is therefore of importance to investigate in what way the healthy brain processes time reference. In non-brain-damaged people (discourse-related) differences in the processing of past and non-past time reference have also been found (Faroqi-Shah & Dickey, 2009; Dragoy et al., 2012), which suggests that the PADILIH applies to the normal language system, as well as to the language system after brain damage. Faroqi-Shah and Dickey (2009) gave agrammatic aphasic speakers and healthy control participants a grammaticality judgment task with tense violations. Their materials included sentences with tense violations on simple verbs of the following type: *Last year, my sister *lives in Boston*, violations by present tense auxiliaries such as: *Yesterday, the honors student *will know an answer*, and violations by past tense auxiliaries as in: *Next year, my younger step-sister *did not live in Boston*. Healthy participants and agrammatic individuals found it easier (reflected in shorter reaction times) to detect violations of past context by present tense verbs than violation of non-past context by past tense verbs. Additionally, reaction times were shorter when the past or non-past tense was marked on the auxiliary (the first part of a periphrastic verb form) than when it was marked on a simple verb (a single lexical verb form), although accuracy did not differ in these conditions.

1.2.2 ERP studies on time reference

ERP studies that have used verb violations focused on morphological processing rather than time reference per se (see Dragoy et al., 2012 for a summary). There are two ERP studies that use true time reference violations, one by Baggio (2008) and one by Dragoy et al. (2012),

both on Dutch.² Baggio (2008) used visually presented sentences in Dutch in which a temporal context was set by an adverbial phrase that was violated by a verb in present tense, such as: *Afgelopen lente *wint/won Julian een literatuurprijs in Frankrijk*: ‘Last spring Julian *wins/won a prize in literature in France.’ He found brain responses typically evoked by morphosyntactic mismatches: a left anterior negativity (LAN), associated with detection of morphosyntactic and word form violations (Neville, Nicol, Barss, Forster, & Garrett, 1991). Additionally he reported a P600, which, among other syntactic violations (Osterhout & Holcomb, 1992), is elicited by violations of a morphosyntactic relation involving locally bound pronouns (Osterhout & Mobley, 1995; Harris, Wexler, & Holcomb; for more background, see Dragoy et al., 2012). This is in line with the claim that processing present time reference, like processing locally bound pronouns, does not involve discourse linking. The P600 is generally argued to be a marker of sentence reanalysis and repair (Osterhout, Holcomb and Swinney, 1994, Friederici, Hahne, & Saddy, 2002; Hagoort, 2003a; Kaan & Swaab, 2003) but has recently also been linked to integration of lexical information with the contextual semantic representation (Brouwer, Fitz, & Hoeks, 2012; Kuperberg, Sitnikova, Caplan, & Holcomb, 2003). Furthermore, Baggio found a broadly distributed negativity between 400 and 700 ms after the final word of the sentence, which he attributed to the brain’s attempts to compute a meaningful sentence.

However, Baggio (2008) showed the effects of violation of time reference only for (locally bound) present tense verbs in a past context. Violations by past tense verbs are predicted to be processed differently under the PADILIH, since they are discourse-linked rather than locally bound. A direct comparison between these two cases was made by Dragoy et al. (2012). Examples of the sentences are given in (3) and (4), with the critical verbs in bold (critical clause in square brackets, with the second adverb a time reference violation by the verb).

²In a study by Fonteneau, Frauenfelder and Rizzi (1998), time reference violations of a past context by a future verb were used. However, these authors used a different ERP measurement paradigm, namely average referencing (p.c.). The preliminary effects (a frontal positivity and posterior negativity between approximately 450 and 550 ms) found in this study can, therefore, not be claimed to be the same as or different in scalp distribution from standard ERP effects such as the P600 and LAN, making the study hard to interpret (see Luck, 2005 for more background on this topic).

- (3) De kelner [die nu / zonet de peper **maalt**] krijgt geen fooi.
the waiter [who now / a-moment-ago the pepper **grinds**] gets no tip
The waiter who is now / a-moment-ago grinding the pepper doesn't get a tip.
- (4) De kelner [die zonet / nu de peper **maalde**] krijgt geen fooi.
the waiter [who a-moment-ago / now the pepper **ground**] gets no tip
The waiter who a-moment-ago / now has ground the pepper doesn't get a tip.

Participants showed a P600 effect time-locked to the critical verb in present tense, replicating Baggio's (2008) results, but no ERP effect occurred time-locked to the critical verb in the past tense, supporting the hypothesized dissociation between past and present time reference. At the end of the sentence, a negativity occurred for both sentence types. Sentence final negativity has been reported following violation of morphological errors earlier in the sentences, both due to local binding and discourse-linking (Osterhout and Mobley, 1995; Harris, Wexler, & Holcomb, 2000) and has been interpreted as being related to memory load or processing difficulty. Dragoy et al. (2012) used the same sentences in an on-line grammaticality judgment task. The participants were less accurate and slower in detecting the temporal violations by verbs in past tense with past time reference than by those in present tense with present time reference. In a binary off-line acceptability rating of a) fragments ending at the embedded tensed verb, and b) of the complete sentences, both violated sentence types were judged as incorrect. Taken together with the ERP results, this means that time reference violations by verbs in present tense with present time reference and past tense with past time reference are both detected but they are processed differently on-line. Dragoy et al. (2012) suggested that these different processing patterns are in line with the PADILIH: when a verb form referring to the past is detected, processing load increases, leading to different neural responses because a discourse link has to be made. Non-past time reference does not require this link and temporal violations by a present tense verb evokes an immediate ERP effect and a quicker behavioral response.

1.3 The current study

The ERP studies performed by Baggio (2008) and Dragoy et al. (2012) showed that in a context of past time reference, a violation by a present tense simple verb causes a P600 effect

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when compared to correct sentences. Bastiaanse (2008) and Bos, Brederoo, and Bastiaanse (2011) showed that for agrammatic speakers, periphrastic verb forms with a present tense temporal auxiliary ('has V-ed') are equally difficult as past tense verbs ('V-ed'): both forms (that refer to the past) are harder to produce than simple present tense verbs (that refer to the present). The time reference difficulties that people with aphasia experience are thus irrespective of tense. These findings are consistent with the PADILIH. The aphasiological data suggest that the positive ERP component that was found on the present tense verbs of the Dragoy et al. (2012) study was caused by a disruption of local binding of time reference expressed by the verb form rather than its tense. In the current study, we aim to find support for this hypothesis by testing violations with periphrastic verb forms, so that tense and time reference can be teased apart. We formulated two predictions based on past results and the PADILIH. Examples of the contrasting sentences are given in Table 1.

Table 1: Examples of the six experimental conditions. Note that the condition NonPast-PeriPast does not contain a violation, because the past that is being referred to by the verb is relative to the reference time of the sentence. The event time can lie in between the utterance time and the reference time.

Condition	Tense	TR Adverb	TR Verb	TR violation?	Example
(1) SimplePast-Congruent	past	past	past	No	De kelner die zonet de peper maalde krijgt geen fooi. the waiter who a-moment-ago the pepper ground gets no tip <i>The waiter that a-moment-ago ground the pepper doesn't get a tip.</i>
(2) SimpleNonpast-Incongruent	present	past	non-past (present/ future)	Yes	De kelner die zonet de peper maalt krijgt geen fooi. the waiter who a-moment-ago the pepper grinds gets no tip <i>*The waiter that is a-moment-ago grinding the pepper doesn't get a tip.</i>
(3) PeriPast-Congruent	present	past	past	No	De opa die zonet de koffie heeft gemalen zorgt voor zijn bezoek. the grandpa who a-moment-ago the coffee has ground looks after his visitors. <i>The grandpa that a-moment-ago ground the coffee looks after his visitors.</i>
(4) PeriNonPast-Incongruent	present	past	non-past (future)	Yes	De opa die zonet de koffie gaat malen zorgt voor zijn bezoek. the grandpa who a-moment-ago the coffee will grind looks after his visitors. <i>*The grandpa that a-moment-ago will grind the coffee looks after his visitors.</i>
(5) PeriNonPast-Control	present	non-past	non-past (future)	No	De opa die straks de koffie gaat malen zorgt voor zijn bezoek. the grandpa who soon the coffee will grind looks after his visitors. <i>The grandpa that will soon grind the coffee looks after his visitors.</i>
(6) PeriPast-Control	present	non-past	past (of future reference point)	No	De opa die straks de koffie heeft gemalen zorgt voor zijn bezoek. the grandpa who soon the coffee has ground looks after his visitors. <i>The grandpa that will soon have ground the coffee looks after his visitors.</i>

TR = Time Reference

- i) If local binding occurs for present time reference as claimed in the PADILIH, rather than for present tense, we predict that violation of a past time context with a non-past periphrastic verb form elicits a P600 time-locked to the auxiliary, relative to a congruent past periphrastic verb form. This is predicted to be true although the auxiliaries in the two constructions do not differ in tense.
- ii) Based on the findings of Baggio (2008) and Dragoy et al. (2012) we predict that violation of a past time context by a non-past simple verb form will elicit a P600, and that this is comparable to the response to the periphrastic verb forms.

We constructed materials with the sentence structures used by Dragoy et al., except that periphrastic rather than simple verbs were used (see example materials 3 and 4 in Table 1). In contrasting pairs, we kept the context (the temporal adverb) constant, as Baggio (2008) did. This allowed us to compare effects of time reference alone, decoupled from tense effects. If tense morphology but not time reference caused the P600-effect in the studies by Baggio (2008) and Dragoy et al. (2012), this ERP-effect should not appear in the comparison where tense is kept constant (i).

In the comparison between the periphrastic verb forms, two different present tense auxiliaries ('has' and 'will') were compared in past contexts. Since these two forms differ in factors such as word stem, length and frequency, we included two conditions in which both auxiliaries are consistent with the preceding temporal context to ensure that the differences in the primary comparison are due to temporal violation and not to these other factors.

2 Material and methods

The materials for this study were collected within a larger scale project which generated data used for Dragoy et al. (2012) as well. Experimental conditions from that study with a simple target verb were reanalyzed for the purpose of the current study (see examples 3-4 above and 1-2 in Table 1), and compared to experimental conditions with a periphrastic target verb that have not been analyzed previously.

2.1 Methods

2.1.1 Participants

Forty right-handed healthy college students took part in the experiment, all native speakers of Dutch. Eight were excluded from analysis due to excessive artifacts in their EEG signal. The remaining participants (12 male, 20 female) had a mean age of 22.7 years (range 18-31). They had normal or corrected to normal vision, had never been diagnosed with speech and/or language disorders (including dyslexia), neurological impairments or psychiatric disorders, and reported no usage of alcohol, drugs or medications that could influence their performance in the experiment. They were distributed over four lists (3 male, 5 female on each list). They signed an informed consent according to the Declaration of Helsinki following a procedure that was granted approval by the Medical Ethics committee. They were paid €20 for their participation in the experiment.

2.1.2 Materials

The ERP experiment contained Dutch sentences in six experimental time reference conditions, illustrated in Table 1. The first prediction was tested by pairs which contained past (3: PeriPast-congruent) and non-past periphrastic target verbs (4: PeriNonpast-incongruent). A control for possible differences between the past and non-past periphrastic verb forms was provided by pairs containing an adverb referring to the non-past. Both the non-past and the past periphrastic construction are acceptable as to time reference and tense in these sentences (5-6: PeriNonpast-control and PeriPast-control). In order to test the second prediction, pairs of sentences were contrasted which contained simple target verbs which referred to the past (1: SimplePast-congruent) and non-past (2: SimpleNonpast-incongruent) respectively.

To provide these conditions, 160 sentence frames were constructed, each of which consisted of a main clause and a center-embedded subject relative clause in which the violation occurred.³ The noun phrases of the experimental relative clauses were matched for animacy (the subject was animate; the direct object was generally, if semantics permitted, inanimate), concreteness (no abstract nouns occurred in the embedded relative sentence), frequency (9 or

³ In Dutch, the base word order is Subject-Object-Verb. In order to avoid interference with derived word order and a sentence final effect, the violations were tested in center embedded clauses.

more occurrences per million in the Dutch CELEX database for written language; Baayen, Piepenbrock, & van Rijn, 1993) and length (3-10 letters).

Each of the 160 frames were used to construct sets of four sentences differing in the form of the target verb (past vs. non-past) which appeared at the end of the embedded clause and a past or non-past temporal adverb following the relative pronoun of the embedded clause to provide the time reference context. Eighty sentence frames contained simple verb forms. These are the materials of Dragoy et al. (2012); a complete description of these materials can be found there. Two conditions for the current comparison (SimplePast-congruent and SimpleNonpast-incongruent) come from those sets of sentences.

The remaining 80 sentence frames were used to construct quadruplets which provided the other four conditions with periphrastic verb forms described above. Two of the versions contained the present perfect *heeft* ‘has’ + past participle and the other two the future periphrastic *gaat* ‘will’ + *infinitive*. Two versions contained the past temporal adverb *zonet*, which was acceptable with the present perfect form (PeriPast-congruent), but not with the future (PeriNonpast-incongruent). The other two contained the future temporal adverb *straks*, which is acceptable with both the future periphrastic (PeriNonpast-control) and the present perfect (PeriPast-control), interpreted as completed in the future.

Although the periphrastic and simple sentence frames otherwise contained different lexical items and are entirely different sentences apart from the structure, the same eighty verbs were used in both sets. For a complete description of the verb choice see Dragoy et al (2012).⁴ In the conditions with periphrastic non-past, for 7 of the 80 verbs the auxiliary for future reference *zal* ‘will’ was used instead of *gaat* ‘will’. Both auxiliaries are used for future reference in Dutch. Of the 80 verbs used in experimental sentences, 58 contained a transitive target verb and 22 an intransitive target verb. In sentences with an intransitive verb, an adverbial phrase was added to match in length with sentences containing a transitive verb. Intransitive verbs describing a change of state or direction of the subject take *zijn* ‘to be’ instead of *hebben* ‘to have’ as an

⁴ The word forms *heeft* ‘has’ and *gaat* ‘will’ can also be used as lexical verbs rather than auxiliaries: *Hij heeft een boek* ‘He has a book’ and *Hij gaat naar school* ‘He goes to school’. However, because they are frequently used as auxiliaries (log frequency of at least 2.3 in the Lassy Small corpus; Van Noord et al., 2012), the auxiliary interpretation is certainly constructed here.

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auxiliary (Haeseryn, Romijn, Geerts, de Rooij, & Van den Toorn, 1997). This form – with third person singular present tense *is* instead of *heeft* – occurred twice in PeriPast-congruent and (accordingly) twice in the PeriPast-control sentences.

To avoid repetition, the 160 sentence quadruplets were divided over four lists, so that subjects saw only one version. Each list contained an equal number of sentences in each condition; the participants read 20 sentences per experimental condition. Care was taken that the two sentences containing the same verb were not close to each other within the list.

In sum, the participants were presented with 300 sentences, a third of them containing a violation. A subset of 120 sentences were experimental sentences of the current study.

2.1.3 Procedure and EEG recordings

The stimuli were programmed and presented using E-prime (Psychology Software Tools Inc., 2001). Data collection took place in a dimly lit sound-proof cabin where participants sat at approximately 80 cm distance from a computer screen. In the middle of the computer screen, the sentences were presented word by word in black on a white background in 12 point font size. An asterisk marked a fixation point for 500 ms prior to the beginning of each sentence. Words were presented for 240 ms each and followed by a 240 ms blank screen. After each sentence, a row of asterisks appeared for 1750 ms, indicating the opportunity to blink. Participants received the instruction to read each sentence for comprehension and to answer occasional questions about the previous sentence. The questions were simple and randomly appeared after 25% of the sentences; they were meant to check the participants' attention and comprehension. The question disappeared as soon as a response was given, or after a 10 s time out. Participants had to respond by pressing keyboard buttons '1' or '2,' which indicated 'Yes' or 'No' respectively. Each list was divided into six blocks which lasted 7 to 10 minutes each. The participants took a short break after completing a block. Testing took approximately 1 hour in total.

2.1.4 EEG recordings and data analysis

EEG was recorded from 64 electrode sites according to the extended 10-20 system using an elastic cap mounted with tin electrodes (Electro-Cap International Inc.), plus the two mastoid electrodes averaged as offline reference. A ground electrode was placed on the sternum. Bipolar

EOG was measured above and below the left eye vertically and from the left and right canthus horizontally. The impedance of the electrodes was kept below 10 k Ω (mean: 2 k Ω). Offline data processing in BrainVision Analyzer (Brain Products, Munich, Germany) and followed the same procedure as Dragoy et al (2012) which is described in detail in that article (pp. 313-314). The mastoid electrodes served as reference for the averaged waveforms, a 200 ms pre-stimulus baseline was used and average waveforms were computed per person for each condition for each electrode.

The analysis included 43 electrodes divided over 15 regions of interest (ROIs), the same as reported in Dragoy et al. (2012): frontal left (AF3, F3, F7), frontal right (AF4, F4, F8), fronto-central left (FC1, FC3, FC5), fronto-central right (FC2, FC4, FC6), central left (C1, C3, C5), central right (C2, C4, C6), centro-parietal left (CP3, CP5), centro-parietal right (CP4, CP6), parietal left (P1, P3, P5), parietal right (P2, P4, P6), parietal-occipital left (PO3, PO7, O1), parietal-occipital right (PO4, PO8, O2), anterior midline (Fpz, AFz, Fz), central midline (FCz, Cz, CPz), and posterior midline (Pz, POz, Oz).

The same time windows as in Dragoy et al. (2012) were used: 300-500 ms, 500-700 ms and 700-1000 ms time-locked to the critical tensed verb (simple lexical verb or auxiliary) and 300-500 ms time-locked to the sentence-final word. Time windows were analyzed using separate repeated measures ANOVAs for midline and lateral ROIs. Factors in the ANOVAs were violation (for the control comparison PeriNonpast-control versus PeriPast-control this factor should more accurately be called the target auxiliary, since here, no violation occurred), posteriority (with 3 levels for midline analyses and 6 levels for lateral analyses) and laterality (left and right). This factor was not included for the midline analysis. For the analysis at the target verb, the factor context (past or non-past) was included for the periphrastic verb conditions. This allows us to separate effects of differences between the two periphrastic forms, which should show up for both past and non-past contexts, and effects of violation, which should only be present for the past context. If there were significant interactions which indicated an effect of violation was present, further analyses were carried out for the periphrastic and simple violation pairs. For the comparison between the effects on simple and periphrastic verbs, a 2 x 2 analysis was carried out with the factor verb type added to violation. For the sentence-final time windows, all three pairs were included into a single analysis with the three levels past+simple

versus past+periphrastic versus control+periphrastic to investigate interaction effects between the response to past versus non-past in these different contexts.

In the result section, the focus will be on main effects of violation and interactions of this factor with posteriority and/or laterality. Since scalp distribution effects that do not relate to the effects of interest are not relevant for this study, these will not be reported or discussed. Original degrees of freedom are reported and (where appropriate) the Greenhouse-Geisser corrected p -values. The significance criterion was set at $p < .05$.

3 Results

The mean of the participants' correct responses to randomly presented questions in this study was 96% (SD = 0.025%), which suggests that the participants read the sentences attentively. None of the participants was excluded from further analysis based on the behavioral data.

In the sentence-final time window, there were no significant effects or interactions, so these will not be presented further. Below, the results on the critical verbs of the time reference conditions are reported.⁵ An illustration of the grand average ERP waveforms for correct and violation sentences with periphrastic verbs is given in Figure 1. A violation of a past time reference context by the auxiliary of a periphrastic verb with non-past time reference seems to evoke a large positivity with initially, from 300 ms onwards, a broad distribution over the skull. A positivity is also apparent for the simple verbs which violated the past context, which appears to start later and to be somewhat more limited to posterior electrodes (see Figure 2). There is no apparent difference between the two periphrastic forms in the control context where both have correct time reference (see Figure 3). Three time windows will be examined, based on the time windows reported by Dragoy et al (2012).

⁵An analysis on the data with the auxiliaries *heeft* and *gaat*, leaving out 2 instances of *is* and 8 instances of *zal*, did not yield different results from the analysis reported in the body of the text.

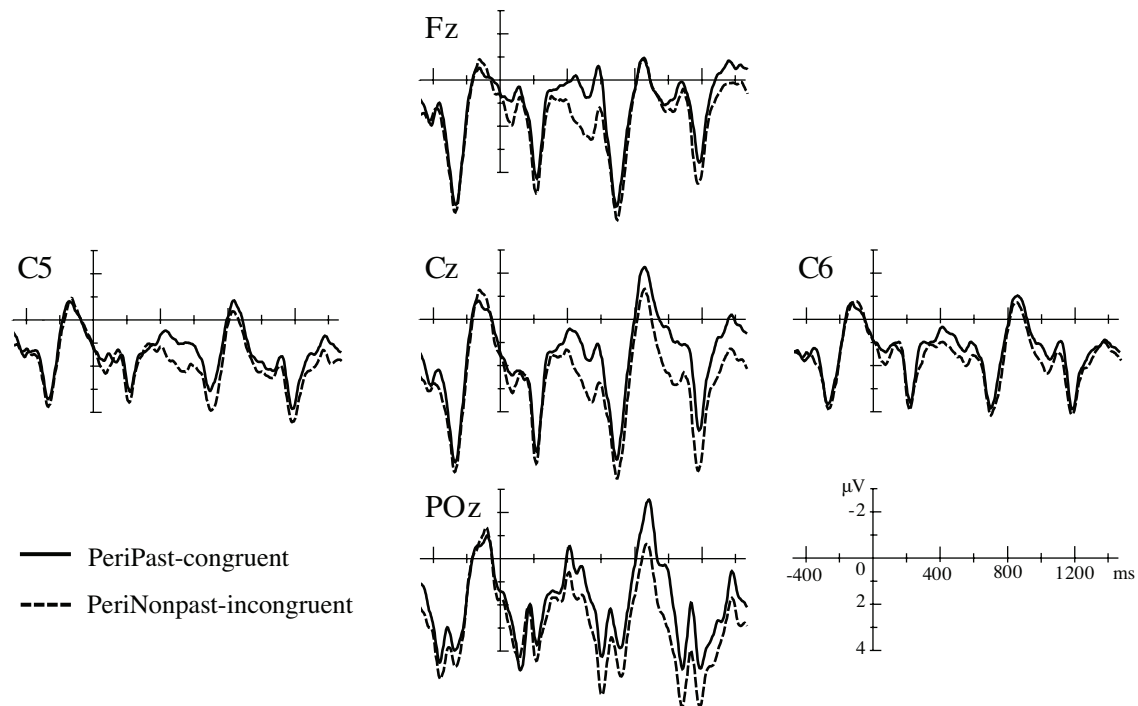


Figure 1: ERPs for conditions PeriPast-congruent vs. PeriNonpast-incongruent. A positivity is seen in response to a time reference violation by the auxiliary in a periphrastic verb, where there is no difference between the conditions with regard to tense. The violation evokes a broad centrally distributed positivity which appears to start around 300 ms. The effect only becomes statistically different from control sentences at around 500 ms, then continues as a more posteriorly distributed effect from around 800 ms.

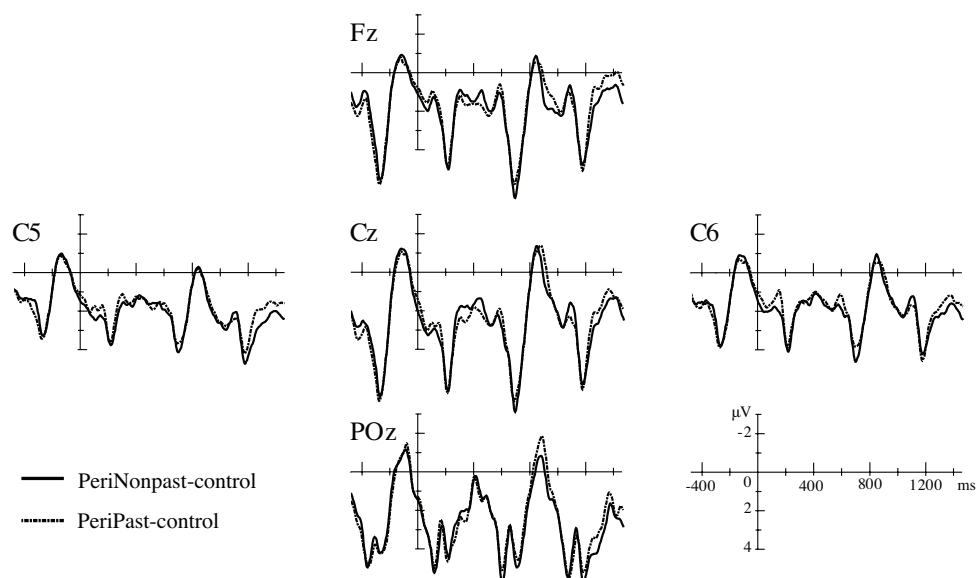


Figure 2: ERPs for conditions PeriPast-control vs. PeriNonpast-control. No difference is seen between past and non-past periphrastic verb forms in the control comparison in which no temporal context violation occurs.

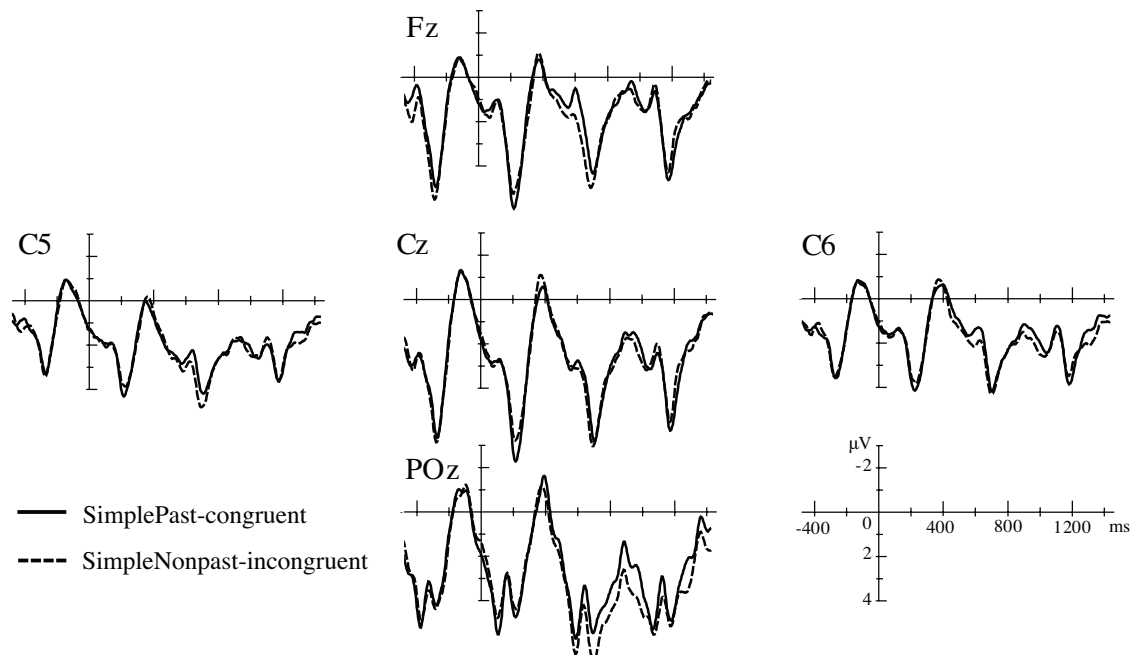


Figure 3: ERPs for conditions SimplePast-congruent vs. SimpleNonpast-incongruent. A positive effect is seen here in response to a time reference violation by a simple verb, for which tense and time reference cannot be distinguished. The effect starts around 600 ms and has a posterior distribution.

3.1 Time window 300-500 ms

Testing the first prediction, sentences with a context of the past adverb *zonet* ‘a-moment-ago’ followed by the present tense auxiliary *heeft* ‘has’ (condition PeriPast-congruent) with past time reference were contrasted with sentences with the same past adverb context violated by the non-past time reference of the present tense auxiliary *gaat* ‘will’ (condition PeriNonpast-incongruent). A significant main effect of violation is apparent over midline ROIs ($(F(1, 31) = 6.00, p < .05)$) and over lateral ROIs ($(F(1, 31) = 4.11, p = .05)$). However, this effect could simply be due to the differences between the periphrastic forms. Control conditions to examine whether this was the case consisted of sentences containing the two periphrastic verb forms following the non-past time reference adverb *straks* ‘later,’ which matches both the tense and time reference of both auxiliaries. This allows comparison of the processing of the present tense verb *heeft* ‘has’ (condition PeriPast-control) with the processing of the present tense verb *gaat* ‘will’ (condition PeriNonpast-control), independent of violation, as illustrated in Table 1.

For the comparison of the effect on periphrastic verbs with the control sentences, an overall analysis was carried out including the factors past versus non-past time reference of the verb phrase (auxiliary), the two temporal adverbs, and the factors posteriority and, for the lateral analysis, laterality. The overall analysis over midline ROIs shows a significant main effect of the temporal adverb ($F(1, 31) = 4.43, p < .05$) and of the auxiliary ($F(1, 31) = 6.08, p < .05$), and over lateral ROIs tendencies for main effects of the adverb ($F(1, 31) = 3.38, p = .08$) and of the auxiliary ($F(1, 31) = 3.74, p = .06$). However there was no sign of an interaction. Since the main effect cannot be attributed to the violation because no differences with the control sentences are found, this time window will not be further analyzed for the simple verbs.

3.2 Time window 500-700 ms

As compared to correct sentences, a past time reference violation by an auxiliary of a periphrastic verb form with non-past time reference shows a broadly distributed positive effect in this time window (see Figure 1). Just as for the first time window, sentences of the condition PeriPast-congruent are contrasted with sentences of the condition PeriNonpast-incongruent. A significant main effect of violation is apparent over midline ROIs ($F(1, 31) = 7.59, p = .01$) and over lateral ROIs ($F(1, 31) = 5.72, p < .05$). A comparison with the control sentences (PeriPast-control and PeriNonpast-control) was carried out in an overall analysis like the one described in 2.2.1 above. Over midline ROIs, this analysis shows a significant interaction of adverb with auxiliary ($F(1, 31) = 4.64, p < .05$), and over lateral ROIs a tendency for an interaction of adverb with auxiliary ($F(1, 31) = 3.35, p = .08$). The interaction allows us to conclude that the positive effect seen after a periphrastic verb which is incongruent with the time reference context is related to the violation and not differences between the periphrastic forms.

To investigate whether the violations by periphrastic verbs are treated the same way as violations by simple verbs, the congruent and incongruent periphrastic forms (first prediction) were compared to the congruent and incongruent simple verb forms (second prediction). Conditions with simple verb forms were correct sentences with a context of the past adverb *zonet* ('a-moment-ago') followed by a simple verb in past tense with past time reference such as *maalde* 'ground' (SimplePast-congruent), contrasted with sentences with the same past adverb context violated by a verb in present tense with non-past time reference such as *maalt* 'grinds'

(condition SimpleNonpast-incongruent). An illustration of the grand average ERP waveforms for correct and violation sentences with simple target verb forms is given in Figure 3.

The overall analysis comparing periphrastic and simple verb forms included the factors of verb type (periphrastic versus simple), violation, posteriority and, for the lateral analysis, laterality. There was a main effect of violation (midline analysis: $F(1,31) = 10.66, p < .01$, lateral analysis: $F(1,31) = 6.36, p < .05$), an interaction of verb type with posteriority (midline analysis: $F(2,62) = 5.87, p = .01$, lateral analysis: $F(5,155) = 9.57, p = .01$) and an interaction of verb type with laterality ($F(1,31) = 10.33, p < .01$). There was no interaction between verb type and violation or of the two with distribution factors (all p 's > 0.38). The main effect of violation without interactions suggests that the violation is treated the same way for periphrastic and simple verb forms. They both evoke a positivity.

3.3 Time window 700-100 ms

The positive effect of time reference violation by periphrastic verb forms continues in the last time window and becomes larger over posterior electrodes from around 800 ms on (see Figure 1). The effect for simple verbs is larger over posterior electrodes (see Figure 3).

In the analysis directed at time reference violation by periphrastic verb forms, a significant main effect of violation was found over midline ROIs ($F(1, 31) = 4.88, p < .05$) and over lateral ROIs ($F(1, 31) = 5.26, p < .05$). Furthermore, the factor violation interacted with the factor posteriority over midline ROIs ($F(2, 62) = 8.49, p < .05$) and over lateral ROIs ($F(5, 155) = 10.11, p < .001$). The interaction is caused by the posterior distribution of the effect (see Figure 1). The distribution and timing of the positivity are characteristic of the P600. This effect is not seen in the control conditions; in the overall comparison the midline analysis shows a significant interaction of adverb with auxiliary ($F(1, 31) = 4.87, p < .05$) and of adverb with auxiliary and with posteriority ($F(2,62) = 5.13, p < .05$). In the lateral analysis there was a significant interaction of adverb with the factors of auxiliary and posteriority ($F(2, 62) = 6.31, p < .01$) and a tendency for a main effect of adverb ($F(1, 31) = 3.37, p < .08$). Similar to the previous time window, due to the interactions the conclusion can be drawn that the positive effect seen after a periphrastic verb violation is related to time reference and not the differences between the periphrastic verb forms.

Since this was the case, the effect of violation for periphrastic verbs was again compared to the effect for simple verbs seen in Figure 3. The positivity for simple verbs also continues until the end of the time window. The overall analysis comparing periphrastic and simple verb forms shows a main effect of verb type (midline analysis: $F(1,31) = 17.91, p < .001$, lateral analysis: $F(1,31) = 22.93, p < .001$), a main effect of violation (midline analysis: $F(1,31) = 6.98, p = .01$, lateral analysis: $F(1,31) = 6.36, p < .05$), an interaction of violation with posteriority (midline analysis: $F(2,62) = 10.01, p = .001$, lateral analysis: $F(5,155) = 10.30, p = .001$), and an interaction of verb type with posteriority (midline analysis: $F(2,62) = 27.16, p < .001$, lateral analysis: $F(5,155) = 20.82, p < .001$). However, there were no significant interactions between verb type and violation, alone or together with either of the scalp distribution factors (all p 's > 0.34).

4. Discussion

Consistent with the PADILIH, the time reference difficulties that people with aphasia experience are irrespective of tense. The PADILIH was extended to healthy language use by Dragoy and colleagues (2012), but that study did not clearly show that the difference was between past and non-past time reference rather than past and non-past tense. The goal of the current ERP study was to shed light on whether the positive component in the ERPs evoked by tense violations (Baggio, 2008; Dragoy et al., 2012) is caused by tense per se or by the time reference value of the verb in its context.

4.1 Results in relation to the predictions

The first prediction was aimed to address the critical issue. If the P600 reported in studies to tense violations (Baggio, 2008; Dragoy et al., 2012) was not caused by violations of tense as such, but by violations of time reference, a time reference violation which cannot be due to tense should also elicit a P600. As predicted, a violation of past time context (*zonet*: 'a-moment-ago') by a present tense auxiliary evoked a positivity when it signaled a time reference violation. Although the positivity effect seems to start earlier for periphrastic verbs than for simple verbs, this cannot be proven because the effect does not differ from the control sentences until the 500-700 ms time window onwards. Visual inspection showed that initially the effect had a central distribution, which turns more posterior from around 800 ms on and last until the end of the

analyzed time windows, matching a P600 effect. The change of distribution is supported by the additional interaction with the scalp factor anterior to posterior in the 700 to 1000 ms time window. The scalp distribution is important, because it suggests that the earlier and later positivities have partially different sources within the brain. The positivity effect is illustrated for the POz-electrode in the upper part of Figure 4.

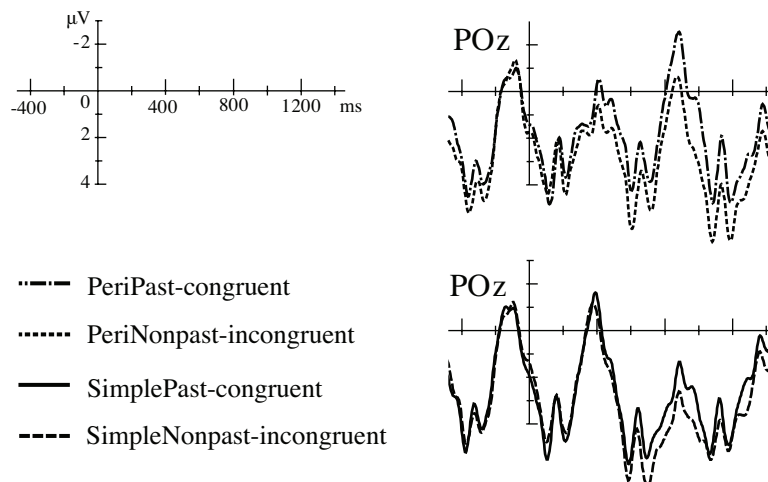


Figure 4: ERPs for periphrastic and simple verb forms. The positivity caused by a time reference violation on the auxiliary of periphrastic verbs forms (above) and simple verb forms (below) for POz, a posterior midline electrode.

The second prediction was that a violation of past context by a present tense simple verb will be treated as a violation and evoke a P600 effect because time reference and tense cannot be teased apart. This effect was indeed present in the current results for simple verbs, starting around 600 ms and was similar to the effects described by Baggio (2008) and for a slightly different contrast by Dragoy et al. (2012). The P600 effect is illustrated for the POz-electrode in the lower part of Figure 4. The effects in the later time windows are clearly comparable.

For conditions with periphrastic verb forms, just as in the second comparison with simple verb forms, the adverb *zonet*: ‘a-moment-ago’ sets the reference time to some earlier point in the discourse. When an auxiliary comes in (*heeft* ‘has’ in condition PeriPast-congruent and *gaat* ‘will’ in PeriNonpast-incongruent), the time reference options become clear even before the lexical part of the verb phrase is encountered. When the auxiliary is part of a periphrastic construction that refers to the past (*heeft* ‘has’), the discourse link can be successfully made. No violation of local binding of the *present tense* occurs, because the time reference expressed

through the periphrastic verb form can be set to the *past*. Thus, the periphrastic past form and the simple past form behave similarly in this respect. However, when an auxiliary inflected with present tense cannot be used for past time reference (e.g., *gaat* ‘will’), there is no possibility for discourse information to render the sentence correct, and a morphosyntactic violation effect (P600) occurs. These results are completely consistent with the first prediction made above on the basis of the PADILIH (Bastiaanse et al., 2011.)

The third comparison was meant to control for any effects caused by the auxiliaries. There is no reason to expect that a P600 effect would occur on the auxiliaries *heeft* ‘has’ compared to *gaat* ‘will’ in a non-past context. When a non-past temporal context (set by *straks* ‘later’) is used, these auxiliaries of time can both be used to build an interpretable temporal model of the sentence. Any difference in this comparison would be due to differences between the auxiliaries, which should then be taken into consideration in interpreting the effects found in the comparison with an incongruent periphrastic verb form. No ERP effect was found upon encountering the auxiliaries. This means that the P600 found on *gaat* ‘will’ (compared to *heeft* ‘has’) in the past time reference context was not caused by the mere fact that the auxiliaries differ in characteristics such as length, frequency and their visual appearance, but is the result of a violation of time reference.

The results of the periphrastic constructions tested here give us a clear picture. Tense violations only cause a positivity if they lead to an incongruent time reference. In that case they lead to a response which is very similar to the one elicited by the ‘tense’ violations reported in the literature. This entails that the positivity evoked by simple verb forms such as **maalt* ‘grinds’ compared to *maalde* ‘ground’, and the positivity found in previous studies (Baggio, 2008; Dragoy et al., 2012) are caused by the time frame that the verb refers to and not by tense. Tense and time reference values may overlap, but they do not always do so. Dutch proved to be a suitable language to disentangle the two. The stimuli of the current study thus provided a testing ground to tease time reference and tense apart.

4.2 Sentence-final effects

A last topic to address is what happens at the end of sentences. Both Dragoy et al. (2012) and Baggio (2008) reported a sentence-final negativity. No sentence-final negativity emerged in the current study. Negativities are sometimes seen after conditions in which referential violations

occur (Osterhout & Mobley, 1995; Baggio, 2008; Dragoy et al., 2012), but are also occasionally seen after other violations such as gender mismatches (Molinaro, Vespignani, & Job, 2008), gender agreement and semantic violations (Hagoort, 2003b), anomalous lexical items and morphosyntactic anomalies (Osterhout and Nicol, 1999). Taken together, as argued in Dragoy et al. (2012), these negativities do not appear to be specific to referential violations but rather reflect the extent to which processing difficulties can or cannot be resolved. In Dragoy et al. (2012), they appeared after time reference violations, but not after typical N400 and P600 control sentences. It remains unclear whether the lack of sentence-final negativities in the current study is because the violations by periphrastic verbs are different from those by simple forms. However, the analysis in which simple periphrastic and control sentences were all compared did not show any sign of an interaction at the final word in the sentence. Thus, there is certainly no basis to suggest that they do differ systematically.

4.3 Conclusion

This study shows that in a context of past time reference, it is the time reference value rather than the tense value of a verb that causes the positivity seen in the ERP responses. Both simple verbs and auxiliaries of time evoke a P600 in such a context. Reference to the past through a present tense auxiliary-participle complex and through past tense can both be used as a baseline in these violations, meaning that they behave similarly.

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